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SOCIAL GROUPS, SELECTIVE PERCEPTION, AND BEHAVIORAL CONTAGION IN PUBLIC OPINION

Michael A. KRASSA

University of Illinois *

The paper describes the results of computer simulations of behavioral contagion in the realm of public opinion. Using threshold models to describe how and why some people assert opinions and others do not, the paper argues that to better describe the dynamics of opinion assertion and quiescence the model must be able to account for the fact that different individuals differ in the importance they place on the actions of others, and in the networks in which they are embedded. The paper reports on simulations incorporating these aspects into the model, yielding an improved representation of public opinion dynamics. Further, the incorporation of networks and weighting systems in the model alleviates one of the problematic features of the simple threshold models described by Granovetter, namely that certain individuals play unrealistically key roles in the contagion process. When networks are accounted for, the threshold formulation is less likely to make the group dynamic so dependent upon the behaviors of specific individuals.

1. Introduction

Individual decisions and behaviors are the product of both predispositions deriving from individual level characteristics and of influences emanating or deriving from the larger environment. The literatures on contextual and environmental influences demonstrate the general importance of aggregate level characteristics, and the Noelle-Neumann notion of the spiral of silence (1974, 1977, 1984) suggests how the behaviors of aggregates interact with individual perception and predispositions to shape the levels of opinion assertion in the environment independently of the real distribution of preferences.

The spiral of silence, a key concept in this paper, hinges on the idea that individuals have an inherent fear of social isolation. Noelle-Neumann suggests that a fear of isolation may keep individuals from

* Department of Political Science, University of Illinois, 361 Lincoln Hall, 702 South Wright St., Urbana, IL 61801, U.S.A.

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voicing their opinions when they do not observe a certain minimal level of support among the appropriate public. Thus, she indicates, each person assesses the environment, observes the level of support, and decides whether to remain silent or assert the position.

In the framework, observing the environment means observing who (or how many or what proportion) *both* supports some position *and* is willing to voice his position; a supporter who does not voice his view is not counted among the supporters by the casual observer—only those willing to make their views public may be counted as supporters. Thus the environmental influences in the spiral of silence theory are based on subjective perceptions of the level of support. True support levels for some position may differ greatly from the levels of assertion (of support) in the public. Indeed, there may be no correlation at all between assertion levels and support levels, as Noelle-Neumann demonstrated with examples from West Germany.

West German Christian Democrats were less likely to publicly express their positions, while Socialists were quite vocal. This led to a great many misperceptions, and generates an over time dynamic in which vocal support for the Christian Democrat position is nearly silenced and public discourse is dominated by advocates of the Socialist position. This dynamic is the spiral of silence after which Noelle-Neumann named the theory (1984: 5).

D. Garth Taylor (1982) makes an important additional contribution when he observes that the individual both influences and is influenced by the apparent global opinion environment. Like Noelle-Neumann, he notes that individuals take their cues from the environment, and borrows from the idea of pluralistic ignorance the notion that those opinions having the most visible (*i.e.* vocal) adherents appear to an observer to be more widely held opinions than is actually the case. He further informs us that "[t]he act of self expression, however, changes the global environment of opinions, altering the perceptions of other persons and, ultimately, affecting their willingness to express their own opinions" (1982: 311). The system he describes thus includes a feedback through which individual behaviors create a global opinion environment which influences the behavior of others. In making the decision to voice one's view, a person is not only influenced by those already voicing the view (who, how many, or what proportion), but also alters the environmental cues that others are taking in making the similar decision.

2. Threshold models

The dynamic is thus based on the property that each individual has some propensity to assert his or her views, and that the decision to express oneself depends on the number of proportion or others who voice support for that position. These two properties conform perfectly with the requirements for threshold models of behaviors which depend in part on group dynamics or behaviors.

Threshold models, developed most extensively by Granovetter (1978) using the examples of riots, begin with the assumption that individual behavior depends on the number of people already engaging in that behavior. The model requires that each individual in the population has a threshold for joining those already mobilized (*i.e.* already rioting in Granovetter's analogy); simply stated, the threshold is the number of others a person must observe in a riot before the person will himself join. Too few rioters (below threshold), and the observer will not join; but when there are enough others in the riot to satisfy the person (*i.e.* the riot size exceeds his threshold), the person will join with the rioters. In essence therefore, Granovetter's argument is that the more risk averse the individual, the more people he must see participating in the riot before he will consent to join. Granovetter continues with a demonstration that the "equilibrium" size of the riot (the size above which the riot will not grow) depends only on the exact distribution of threshold across the relevant population.

The case of contagion in the public expression of opinions is exactly analogous. An individual, for fear of social isolation, must observe some minimum level of support for an issue or position among the population before he or she will publicly display his private preferences. The level of public support that an individual requires be present in the population before he too will assert or publicly display his own support for the issue is exactly the threshold that Granovetter uses in his development of the riot case. Thus, the visible level of opinion assertion or display depends in large part on the distribution of thresholds across the population, just as the "equilibrium" riot size depended on the similar distribution for that behavior. Opposition to a proposal and silence on the issue are treated similarly, as non-support, which allows the logic of the threshold model to apply.

The questions of the intensity of a person's opinion and the willingness to assert one's opinion are tightly bound together. In general, it is

thought that people with more intensely held preferences are most likely to express their opinion, while those with less intense preferences or opinions are more influenced by the behaviors of others. O'Gorman (1975) notes that perceptions of majority support for some position have a greater impact on those who are less intense and less extreme in their views. The intensity of preference is an important determinant of one's "threshold" (in Granovetter's sense) for opinion assertion: persons with more intensely held positions have lower thresholds, *i.e.* they are more willing to speak out *on that issue*, even in the face of apparent opposition, than would be the case for issues on which their preferences are less strong (or for people with weaker preferences on that same issue).

The mechanics of threshold formulations are easily seen through an example. Given 10 supporters of some view, each with a threshold for voicing their support for the view, expressed in terms of the number of other supporters that must have already vocalized their agreement, the dynamic of the unfolding of opinion assertion using a threshold model may be illustrated. Other supporters with thresholds greater than 10, and opponents of the view, may or may not be present in the population, and their existence or absence is irrelevant to the example as this depiction uses numbers rather than proportions. The thresholds of the ten are ordered as follows:

(0, 1, 2, 2, 4, 5, 5, 7, 10, 11)

The first individual has a threshold of zero, indicating that he is very willing to risk social isolation and will assert his views even if there are no other supporters in sight. This person initiates the behavior (in this case, vocalizing the opinion), for he is willing to speak up regardless of whether he finds support among the public or not. This is the evangelical, the fanatic, or a person who simply enjoys hearing himself.

The second individual, having a threshold of 1 indicating he is somewhat less risk acceptant, needs to see at least one other person willing to voice support for the proposition before he too is willing to speak his mind. For this person, the first individual (with threshold 0) satisfies that requirement, and thus he too asserts his opinion. Thus, in the two elapsed iterations, two people have gone from "silence" on the issue to asserting their support.

In the next iteration two more people vocalize their opinion, for a total of four vocal supports, with six supporters yet remaining silent.

The two who decide that there is now an adequate level of support for the position and that they too should now speak out are the ones with threshold levels of 2. The two people who began earlier (*i.e.* the ones with thresholds 0 and 1) satisfy the condition set by the threshold of the third and fourth supporters.

With four supporters now visible, the person with threshold 4 will express his support, making a total of five voicing support. This then allows the next two individuals to join, as they each have the threshold value of 5. Support then stands at seven, and the individual with threshold 7 will also join, for a total of eight supporters who find sufficient public support to voice their opinions.

In this example, there are ten supporters of the position, yet only eight are willing to express their support publicly. Two individuals, those with threshold values of 10 and 11, do not find sufficient support in the population for them to make their views known. Thus, they remain "silent" supporters of the proposition, forever feeling that the proposal has inadequate support for them to voice their preferences for it. An observer, looking over the population, might easily be led to think that there are only eight supporters of the view in the population (rather than the ten), much as one might have suspected there to be many fewer Christian Democrats in West Germany in the 1960s than there actually were.

The critical element in both the above example and in most threshold models of behavior is the distribution of the thresholds across the population. The observed (or voiced) level of support for some position will be determined by the way that the thresholds are distributed. In the example, the "equilibrium" level of support was 80 percent of the potential because the thresholds were distributed in a way that did not enable the most risk averse among the supporters to overcome their fear of social isolation and voice their support.

In general, the cumulative distribution of thresholds across the relevant population can be examined to determine both the rate of growth and the "equilibrium" level of the phenomenon in question. Assume that there are a fixed number of supporters of position X in the population; call this N_X. Then one need examine the cumulative distribution (c.d.f.) of thresholds for supporters of X to determine the numbers of *vocal* supporters. If the cumulative distribution is given by f_x then $f_x(0.05)$ gives the proportion of supporters with thresholds below 5 percent—*i.e.* the proportion of supporters who will make their

support public if 5 percent of the population is already voicing support. Thus, if $f_x(0.05) = 0.15$, 15 percent of the supporters will speak out if 5 percent are already vocal in their support; more generally, $f_x(r) = q$, where q gives the proportion of supporters with thresholds less than or equal to r in a population where the c.d.f. of thresholds is described with f_x.

Alternatively, one might rewrite $f_x(r) = q$ as a difference equation description of the process. Using forward recursion, the number of vocal supporters at one time can be computed directly if the threshold c.d.f. and the number of supporters in the previous time period are known (Granovetter 1978). Thus, the process is described by $f_x(q_t) = f(q_{t+1})$: if there are q_t supporters of the proposition at time t, there must be q_{t+1} at time $t + 1$. The dynamics, therefore, are completely contained in and determined by f_x. This is more or less consistent with Taylor's (1982) argument that individuals take their cues from public opinion, but that public opinion is a direct function of the numbers or proportions of people who have decided to express themselves.

Threshold models of any phenomena, including the contagion of opinion assertion and the spiral of silence, thus contain the entire dynamic of contagion in the form of the cumulative distribution of thresholds over the population. The cumulative density function controls *both* the rate of behavioral contagion (in our case, voicing a preference for some specific position) and the level at which contagion will cease. (Granovetter (1978) and Granovetter and Soong (1983) refer to these levels as the "equilibrium" levels. More precisely, these are maxima, or sometimes minima, or simply limits; levels beyond which the behavior, for one reason or another, will not spread. The meaning of the term equilibria suggests properties which these "points of cessation," maxima, or minima do not always display, and hence the term is not fully applicable within the threshold formulations.)

3. Threshold distributions and opinion assertion

The exact distribution of thresholds over the population of supporters (of some position) determines the observed aggregate behaviors—the "public opinion" in this case. The shape of the distribution controls both the dynamics of opinion change and the stable levels of opinion assertion in a population. By definition, when $f_x(q_t) = q_t$ there is no

increase in the numbers of supporters expressing their opinions, and there is no net change in the level of support: if the number willing to vocalize their opinions if q_t are already doing so is also exactly q_t, then there is no change in the support level. Thus, this is a period of stability in public opinion: there is no change between time t and $t+1$ in the level of support, *i.e.* $f_x(q_t) - f_x(q_{t+1}) = 0$.

Further, both the threshold models and the theory of the spiral of silence demonstrate how public opinion may change without a corresponding change in the distribution of preferences across a population. If public opinion is a measure of expressed opinions, the change of some from silent to vocal supporters is a change in "public opinion" with no corresponding change in the *actual* public preferences.

Examinations of hypothetical threshold distributions are easily conducted using either simulation or analytic techniques (see, for example Granovetter and Soong 1983; or Krassa 1986). Such examinations reveal that great volatility can exist in a population with an unchanging distribution of preferences, due to the way that thresholds are distributed across that population. It is also possible that a threshold distribution can result in an overwhelming sentiment remaining unexpressed in a population because of a lack of low threshold individuals. In fact, it is theoretically possible that a position receiving unanimous support remains totally unexpressed in the population because all individuals have high thresholds; no person is willing to risk being the first to voice support for the idea.

Thus, these theoretical and other "laboratory" explorations make it clear that the distribution of thresholds has a large impact on what we observe and how "what we observe" might differ from "what really is." This is especially critical in the case of public opinion, where we see that measures and estimates of public opinion not only influence individual behaviors of common citizens, but also have impact on the behaviors and decisions of current and potential local and national policy making elites.

Examples of the feedback into policy and policy making are plentiful. The potential "dark horse" presidential candidate, whose candidacy would receive tremendous support because almost everyone likes him, may decline to run in the primaries because public support is not evident as a result of too few supporters with low thresholds to get the campaign off the ground. Few are willing to back him since all that can be "seen" are the small number of vocal supporters. What isn't known

is that if there were just a few more "initial" supporters, his campaign would "take off" with what political commentators often refer to as "momentum."

Obviously, legislators are influence by the dynamics of the spiral of silence as well. Viewing a populace that has many vocal supporters of proposition X, the legislator may endorse or sponsor legislation favorable to X. It is possible, however, that X is not really preferred by the majority of his district, just as the Socialists were not really preferred by a majority in West Germany (Noelle-Neumann 1984). Thus, the legislator has unknowingly hurt both himself and his district in the effort to carry out the function of representation.

These vignettes are presented as possible consequences of the dynamic presented as the spiral of silence; the threshold model formulations suggest that these are real possibilities. However, to date, empirical tests of the hypotheses have proven difficult. In part this is because empirical tests would require detailed information about the population and how thresholds are distributed across it. Even a small "gap" in the distribution may have serious consequences for the contagion of opinion assertion, as was demonstrated in the brief example at the beginning of this paper. Thus, one must have information about the population which is more detailed than is likely to come from the "average" sample survey.

Though techniques exist for measuring an individual's "fear of social isolation" (Noelle-Neumann 1984), they need to be implemented at a very high density across the entire population. Further, one would need to know the "true" distribution of opinions across the population, rather than just the distribution of opinions across vocal portions of the populations. Clearly, it is a tricky proposition to measure opinions in the portion of the population which refuses to voice opinions for fear of social isolation. Of course, there are methods in survey research for minimizing contamination due to a social desirability bias, and these might fruitfully be implemented here. However, their effectiveness is sometimes uncertain, and again one can see that the problems of empirical testing are serious, requiring large and expensive interview projects, likely using complex and sometimes uncertain procedures.

4. Social groups and selective perception

The theory, as developed by Noelle-Neumann and translated into the logic of threshold models stands as an attractive and nearly irrefutable statement. The logic of the model is direct and compatible behavioral illustrations are easily found. A major problem emerges, however, because information travels through networks and is context dependent. In the theory of public opinion, the notions of social groups and selective perception are important references to the fact that individuals are not globally aware or concerned. People both place more importance on the activities and positions of some social groups, and they are more aware of the activities, behaviors, and preferences of some people than others. Thus, in order to assess the social support necessary before a person will voice the view, the character of those already vocal must be considered.

In short, it does not matter how many are voicing a view if their existence is unknown to a person. It will not overcome my "fear of social isolation" and thereby ease the psychological barriers to my voicing my own view if there are 10,000 who agree with me but I am ignorant of their existence. Further, it is only somewhat better if I am aware of their existence, but they belong to a social or political grouping or class with whom I almost never agree or about whom I care nothing. Thus, the simple logic of the threshold model, while appealing, fails to capture the full dynamic involved by ignoring the fact that individuals weigh the actions and opinions of others differently.

Both of these factors are known to be important, and their roles in both behavior and opinion dynamics have been confirmed in numerous studies. However, they present serious problems to the "threshold model" representation of Noelle-Neumann's thesis. The *representation* of neither social groups nor selective perception is a great problem, but the model's mathematics become intractable with most representations that include these important phenomena.

Incorporating the fact that a person attaches more importance to the actions of some individuals than others, and to the actions of some *types* of people (*i.e.* some social groupings or classes) than other types, is easily accomplished with a straightforward weighting system. Since each individual has a threshold against which public support for a position is evaluated, it makes sense to suggest that some individuals'

behaviors weigh against the threshold more heavily than others. I might voice my preference for position X if the 25 other supporters already speaking up are people for whom I have great respect, while it might take 100 other people to overcome my threshold. Thus, it is easily seen that one of the 25 revered few count four times as much as the others. It takes many fewer of them to induce me to voice my opinion because of the reverence I place on their actions. Thus, they count more against my threshold than others.

This one modification has no real effect on the heuristic. One still indicates than an individual decides whether or not to voice an opinion by considering the currently vocal population. If the population is above an individual's threshold value, then the person asserts his agreement with that group. However, it is no longer true that all vocal individuals in the assertive portion of the population count the same in everyone else's calculations, nor do all assertives necessarily count the same in any one person's calculation. In other words, I value the actions of some people more highly than other's, so they "count more" against my threshold than do other people. However, not everyone values the same people I do, and the ones who count most against my threshold do not necessarily count most in another person's calculus.

Thus, there is only a small modification in the description of a the calculus at the individual level. However, this small change in the decision rule at the individual level adds tremendous complexity to attempts at modeling the aggregate behavior. The threshold model proposed by Granovetter remains a very useful analogy, but the difference equation representation is now either impossible or intractable. What drove the difference equation model of aggregate behavior was that each person's decision calculus used the same "data:" each person counted the size of the assertive or vocal portion of the population the same. Thus, the cumulative density function of thresholds and the proportion of the population choosing to assert their opinions were linked in a simple manner because thresholds all responded to the same observations.

The modified version of the individual calculus, however, in essence means that different people count up the number or proportion of opinion asserters in the population differently. Because some people are more important than others to me, and because different (silent) individuals will evaluate the various opinion asserters differently, each person will have a different view of the proposition's vocal supporters.

Some will, in essence, count more of them, which means that it is no longer the case that if two people have the same threshold, they will "see" the same number of opinion asserters in the population, and therefore make exactly the same decision (at the same time). This occurs because, though the two people make use of exactly the same decision calculus, they are using different "data" in the decision making. (More appropriately, they measure the phenomenon—public assertion of support for some position—differently. These different measures produce a different input even though all contend to be observing the same thing. It is exactly the problem that different observers see different things, as we known from the experiments of social psychologists like Asch, Milgram, Sherif, and many others.)

One fruitful way of incorporating both the concept that different individuals vary in the way they value and evaluate the actions of other people, as well as the notion that people differ in their levels of awareness and knowledge about who or how many support some notion is with the notion of "ties" between individuals in networks. Unlike, say, a riot, "public opinion" or support for issue X is difficult to observe except among small groups or very limited populations. It is likely that different people "hear" or 'see" *only a portion* of those supporters of issue X who have chosen to voice their stand. Thus, each individual may be depicted as embedded in a (possibly different) network, where each individual is linked to every other with a "tie" that varies in strength depending upon the relation between the two. Tie strengths between any two individuals A and B are a function of (1) the importance of B to A's decision, and (2) A's awareness of B's activities, in this case, whether or not B has voiced a preference. If A reveres B and is greatly aware of B's activities, then the tie will be very strong, and the actions of B may carry the weight of several less important individuals in the decision calculus of A. In other words, B may be an opinion leader, at least in A's mind, and if several people view B in a similar way, he indeed may be an important opinion leader.

A tie between individuals A and B captures both the importance that A places on the actions of B *and* whether or not B is "visible" to A in any meaningful way. It is possible that, were he aware of B's actions, B might have been important, but that for one reason or another A is unaware of B, which the tie accounts for by being set at strength zero. Greater strengths of awareness result in larger and larger tie strengths. One representation of the ties is to consider two multi-

plicative factors: (1) the level of awareness, which ranges between 0 and 1, and (2), the importance one places on the other, not restricted in range. The "tie" then is the product of these factors, with the "importance" telling how much the actions of B "count" against the threshold of A, discounted by A's awareness of B.

Three further aspects deserve comment. It should first be noted that the notion of importance may capture *negative* influences: the reasoning that "if B supports cause X, then I couldn't possibly voice my support for X because I would never want to be publicly associated with B." (Of course, such a situation may invoke a second important dynamic in which A re-evaluates his position as a consequence of his observation of B.)

Second, it is important to understand that the ties are not necessarily symmetric. The tie between A and B is not restricted to be identical with the tie between B and A. If B is an opinion leader in any area of broad scope or implication, then B may be completely unaware of A's very existence. A is nearly (or completely) irrelevant in B's decision calculus, yet B is central, or at least significant in A's decision making.

Finally, it is important to realize (and almost redundant to state) that all evaluations are subjective. The actions of B are important to A only in terms of A's subjective evaluations of B; B's actual positions and behaviors relevant to those positions are important only in as much are the empirical facts which are then interpreted by A. It is on the basis of a measurement and interpretation of those facts that in reality drives A's decision making and consequent behavior. Various behavioral and psychological theories, and simple common sense, tell us that this is the case; and this is one important aspect of the notion of selective perception.

5. Implications for investigation

The simple, initial model of opinion assertion and quiescence was a Granovetter-style threshold formulation of the spiral of silence notion which is easily formalized and employed. These two further complications, while straightforward, easily described, and relatively simple to include under the logic of some threshold formulations, substantially complicate both empirical measurement and modeling of the opinion assertion problem. The difference equation formalization of the

threshold model, while still possible, is no longer simple, and is mathematically intractable. The cumulative density function of thresholds, f_x, can no longer drive the dynamic as previously. While important in one sense, it does not account for the fact that different observers of "public opinion" will measure it differently. To capture the phenomena labeled "selective perception," "social groups," and "opinion leadership" the model must account for the fact that the "count" of opinion asserters is subjective.

A model of this more complete description of the dynamics of opinion assertion and quiescence requires that several additional terms must be defined and operationalized. Let:

$A_{i|x}$ ≡ the assertion of individual i in issue arena X, $A_{i|x}$ is thus a dichotomous variable taking on the values 1 or 0,
$T_{i|x}$ ≡ the threshold of individual i in issue arena X,
$R_{i|x}$ ≡ the risk aversion or fear of social isolation of i in issue arena X,
$I_{i|x}$ ≡ the intensity of individual i's opinion in issue arena X,
$E_{b|i,x}$ ≡ the importance of or evaluation of individual b vis-à-vis individual i,
$P_{\cdot|i,x}$ ≡ the proportion of the population that individual i estimates is asserting his preference in issue arena X, and
$N_{i|x}$ ≡ the social network or set of people to whom individual i is attentive with specific regard to issue arena X.

Several relationships and identities can now be defined in light of the preceding discussion. First, it must be true that whether or not an individual chooses to assert his opinion is a function of (1) the individual's threshold for assertion on that issue, $T_{i|x}$, and (2) the number and the way that the person counts the number of persons already voicing that position, $P_{\cdot|i,x}$. Thus, a calculus similar to the earlier threshold model applies, except that here the proportion asserting an opinion on issue X is measured subjectively—with the subjectivity denoted with the subscript i.

$$A_{i|x} = f(T_{i|x},\ P_{\cdot|i,x}). \tag{1}$$

Thresholds, as we have noted, are determined by a variety of factors,

most importantly the intensity of i's preference on that issue and his level of risk aversion. Thus

$$T_{i|x} = f(I_{i|x},\ R_{i|x}) \tag{2}$$

indicates that a person's risk aversion or fear of social isolation and the intensity of feelings about an issue both play a role in determining a person's threshold for that issue. As the intensity of feeling rises, thresholds are smaller, but thresholds rise as an individual's aversion to risk increases.

Further, it has also been asserted that different people view the vocal portion of the population differently. In particular we noted that the entire set of those vocal on issue X are visible to individual i, and that there are differences in the importance (to i) of those individuals seen to be vocal. Thus,

$$P_{\cdot|i,x} = f(N_{i|x},\ E_{\cdot|i,x}). \tag{3}$$

The network that one is embedded in determines which other persons individual i can "see," and the fact that the actions of different individuals vary in importance to i is conveyed in the term $E_{\cdot|i,x}$.

Thus, individual opinion assertion is a function of the individual threshold and a measure of the level of assertion in the public, as before, but now the measure of the assertion level is relative and subjective. Each individual measures it differently depending upon who is important to the person and the "social network" in which the person participates. This simple alteration in the logic of the model, however, prevents systemic behavior from being adequately represented as a direct function of the cumulative density of thresholds across the population; a fact which greatly complicates investigation.

The problem in determining the behavior and assertion level of the population is clear: because each individual measures the level of assertion in the population differently, each individual can be conceived as having a different function which translates the actual level of voiced support for a position into some measure that is useful to him. Unless it can be assumed that every person's "translation" is similar, understanding the systemic behaviors requires knowledge about each individual's method for "translating" observation into measurement. The discussion above provides a number of hints, indicating that

knowledge about the relative rankings of people and the networks in which a person is embedded are important. However, such information is neither easily obtained nor easily incorporated in an useful model.

If the networks and social relationships or weightings for every individual (from the perspective of each individual) in the population can be identified, then the process leading to opinion assertion or quiescence can be represented (figuratively or mathematically) as contagion traveling through and conditioned by networks. And, once fully represented, several methods show promise for examining the systemic behavior. Analytic, computational, and simulation techniques may all be useful tools for examining and discovering system behaviors and properties. Each of these means of analysis are complicated by the same factor, namely that the number of possible combinations of networks, weighting schemes among individuals, and threshold distributions becomes unmanageable because, as explorations using computer simulations have shown, slight changes in any of these factors can profoundly alter the results.

6. Simulating contagion

In order to study the basic properties of this elaboration on the spiral of silence, a procedure which incorporated both the "weighting" and "network" ideas (which are themselves "proxies" for the more general notions of selective perceptions and social groups) into a simulation procedure had to be devised. As noted earlier, the notion of the "tie" provides such a vehicle; further, it is easily incorporated into simulations.

The simulations require the assignment of threshold values to each individual in a population. They further require the construction of a population matrix denoting the strength of association between each (directional) pairing in the population. For these simulations, a population of size 100 was chosen, thus requiring the selection of 100 thresholds and a 100 by 100 matrix of pairwise interrelations. These interrelations take into account both the network and the weighting, and are simply the product, for each (directional) pairing, ij, of a network measure which tells how much i knows of j's activity, with a weighting measure for each pair that tells the importance of j's activities to i's decision. The network measure was restricted to the

$0-1$ interval, where 0 indicated that individual i has no awareness at all of j's actions (or possibly, even existence), and 1 is perfect awareness. Networks can be seen in the arrangements of non-zero scores on this measure.

The computer simulations proceeded iteratively through a simple computation and search routine. To "initialize" the process, some individual must be assigned a threshold of 0—this is the person willing to speak up and voice an opinion in the face of no apparent public support. These are the evangelical believers who begin the contagion.

Each person who voices the preference is assigned an assertion value of 1; quiescents are given a value of 0. The computer then calculates, for each individual, i, an evaluation of the social support for the position:

$$P_{\cdot|i,x} = \sum_{j=1}^{n} (A_{j|x}) * (E_{j|i,x}) * (N_{j|i,x}).$$

This says that each individual in the population calculates a subjective estimate of the proportion of the population that holds the view by looking at the population and counting the number of people who agree. However, not every j can be "seen" by every i, as noted by the $N_{j|i,x}$ term which tells whether each j is included in i's "network" or awareness, which is itself discounted by i's evaluation or weighting of j, $E_{j|i,x}$. This product is then multiplied by the 1/0 variable telling whether each j is voicing the position or not $(A_{j|x})$, and these quantities are then summed.

This process is repeated from the perspective of each individual in the population, giving each individual's estimate of the social support for the view, and is the basis of each person's decision. Individuals for whom this subjectively calculated $P_{\cdot|i,x} \geq T_{i|x}$ become assertive, i.e., $A_{i|x} = 1$. Since their subjective estimate of social support for a position is greater than the person's threshold, the person then feels free to voice the view. Finally, the simulation process is repeated through many iterations, until growth in support for a position finally ceases.

7. General properties

Large numbers of these simulations have been run, and some properties of the dynamic of contagion though networks can be addressed

(Granovetter 1978; Krassa 1983). It is important to note, however, that simulations cannot provide the insight of analytic solutions because of the incomplete nature of the simulation approach. Not all combinations and variations of the relevant variables can possibly be considered by a simulation approach; though they do provide a framework for a systematic study, some uncertainty will always remain.

Several distinct patterns emerge in the simulations, all of which point to the sensitivity of dynamic to even small changes in the basic framework of the population and the distribution of thresholds across the population. Granovetter (1978) and others (Granovetter and Soong 1983; Achen 1986; Krassa 1986) have convincingly demonstrated that small changes in the threshold distribution have important consequences for the group dynamic. Indeed, exactly the behavior that Noelle-Neumann (1977, 1984) called the "spiral of silence" can be shown to result from certain threshold distributions in simulated populations. Further, simulations shed some light on how the spiral of silence may be reversed and a highly vocal population might be silenced through nothing other than the removal of (or changes in the thresholds of) a small number of key individuals—individuals who, interestingly enough, are not necessarily the "initiators" (people with $T_{i|x} = 0$). Individuals are key to the "unraveling" of opinion assertion in a population if they are the only one with a given threshold and if they would be the only one to change behavior at a given moment. In other words, the key persons may act as a "switch" on the contagion dynamic; contagion may not continue to persons with higher thresholds unless it has also influenced the decision of the key individual. Further, if the person is key for contagion of assertion, he is also key for the unraveling. His removal from the population (or from the key position by a change in threshold) will quickly result in all those with greater thresholds becoming "silent."

In the simple threshold formulation a key person will be key for the entire population (or at least that portion with thresholds greater than the key person). In the spiral of silence dynamic which accounts for selective perception and different networks among individuals there may be both more stability and instability in the group dynamics. One of the consequences of networks is that a single individual may be "key" only to portions of the population, and thus their removal will affect only some, not all of those in the population who have higher thresholds. Further, since people are "weighted" differentially even by

others in their own network, the importance of a person to the group dynamic is no longer simply a function of his threshold; since he is not counted the same by those who observe him, it is possible for contagion (or the decay of "unraveling") to proceed "around" some people even though they may be key for some group. Thus, the following scenario is possible:

> Individuals W, X, Y, and Z have thresholds N, $N+1$, $N+1$, and $N+2$, respectively. W becomes vocal, which triggers X's own assertion but not that of Y because Y is not in a network which recognizes X. However, because Z recognized both W and X, Z can then voice his view. Finally, if Z is included in a network with Y, Y's threshold of $N+1$ is satisfied by the actions of W and Z.

In this scenario the behavior of Z is influenced before that of Y even though Z has a higher threshold. It occurred only because of the networks, and shows how the cumulative distribution of thresholds is no longer the sole determinant of group behavior, but that its influence is interactive with the influence of networks. This is an important and significant departure from findings which rest only on a threshold model. The incorporation of networks adds greater stability to expectations of group behavior.

Two behavioral characteristics of contagion through networks become clear as a result of simulations. First, the more fragmented the population or the more that separate networks can be identified in the population, the less likely it becomes that a population with large numbers of vocal individuals will be silenced by the removal of one or two individuals from the population. Since fewer individuals can be considered "key" in the population, the population characteristics are less likely to be affected by the removal of any single person.

On the other hand, the converse is also true: among a population with few vocal individuals, the more fragmented the network, the less likely becomes any contagion of assertion. Thus, the more fragmented the networks, the less likely we are to see either sort of change in a population. When networks are highly fragmented, individuals are less likely to alter their own behavior as a consequence of some other individual's behavior.

The logic of this finding is easily understood from either the mathematics of the simulation or from previous research on substantive

problems. As the interrelations among individuals in any population or group become weaker and less dense, the less easily the behavior of the collective can be influenced. As fragmentation increases, the less any individual is influenced by the actions of any other, and the more individual behavior becomes the result of solely individual decisions made in "isolation" from others. It is harder to either mobilize or de-mobilize that population because individual actions are not heavily interdependent. If the group appears to be acting similarly, one might use caution in describing the group behavior as "collective action" even though in observing the group it might appear as such. A better description is that the group behavior might be "synchronized" or "coincidental," terms which suggests that the behavior is similar, but not interdependent.

One of the clearest examples of this is in Gans' (1962) descriptions of attempts to mobilize two separate ethnic communities in the Boston area against urban renewal projects that threatened each of them. In one area, the network among residents was substantial because many of the men shared a common employer. This group mobilized successfully, while the other area was less successfully mobilized because the network connecting individuals in that community was much less dense. Curiously, Granovetter (1978) recognized that this was a key difference in the group behaviors of these two communities, but failed to incorporate this in his threshold model descriptions of group behavior.

Networks likewise influence the rate of contagion across a population. By requiring that contagion, if it is to continue in a population, must follow certain paths between individuals and that only certain individuals influence only certain others, networks slow the pace of contagion. With thresholds controlled, contagion across a population is very rapid in the fully interconnected, ergodic community, but (in the true sense of the word) is impossible in the completely fragmented, atomistic setting (because here, everyone acts in "isolation"). In the range between the ergodic and atomistic settings, the effect of increasing fragmentation is to systematically decrease the rate at which contagion may take place—if indeed the network does not prevent contagion from taking place at all.

Other factors that influence the rate of growth or decay of the level of assertion in some population include the shape of the cumulative threshold distribution and the relative weightings among individuals.

That these factors influence the rate of contagion, however, is somewhat less surprising, even expected from an understanding of the mechanisms of influence. With networks and weightings controlled, for example, growth of decay will be more rapid as the threshold c.d.f. has modal points at low thresholds. In short, this means that there are many people in the population with relatively low thresholds for opinion assertion, all of whom will enter both early and (nearly) simultaneously, in an explosion of support for the position—or in a rapid "silencing" effect. Not surprisingly, this logic is demonstrated behaviorally in simulation tests as well.

Similarly, with the threshold distribution and networks controlled, contagion is more rapid as the ties between individuals become stronger. Again, this is not surprising because the logic of the model requires that this effect be present. If a person counts twice as much as another, then the first person's actions will have a greater influence. Thus, as ties between individuals in a social setting become stronger and stronger (with networks and threshold distributions held constant), contagion proceeds at a faster and faster rate. Conceptually, this is most easily seen if one compares the rate in one simulation where everyone has a tie of 1.0 with another where ties are all of strength 2.0. Naturally contagion will be much faster in the second instance. This latter case is exactly like reducing each person's threshold by one half.

Another factor that influences the behavior of the model is the "differential weighting" among individuals. Conceptually important, the effects of this are substantially more difficult to study (using simulations) than were the consequences of variations in networks. Even with networks held constant, the number of possible weighting among individuals in a population is nearly infinite, making systematic study using technologies like simulation difficult.

Several interesting patterns do emerge from the research, however, though it is almost certain that others exist. One thing that weighting schemes allow is the inclusion of opinion leaders in the model. Opinion leaders may be local in that only some portions of the population look to that individual, or they may be global in that the entire population regards the opinion leader's opinion highly. What is interesting is that as the value placed on an opinion leader increases, the opinion leader becomes more and more a central determinant of group behavior. Though when stated, this sounds obvious from our knowledge of opinion leadership, it is important to know that (1) the differential

weighting among individuals is sufficient to include the concept of opinion leadership in a threshold model, and (2) even though networks act to reduce the chance that a single individual is key to group behavior, weighting differentially to allow opinion leaders is often sufficient to create "key" individuals and overcome the handicap that networks place on their social and political functions.

If opinion leadership is represented as differential weighting in a simulation, so is the somewhat different concept of social groups. Substantively, group identification is an important reason one individual might place more importance on what one person says than another. The common example is social class, though religion, race, occupation, position in some hierarchy may all be important as well.

Simulations again only provide incomplete information about the consequences of social group identifications. However, several trends can be identified. Models that incorporate social groups classify individuals according to group and assume that they are most often likely to weight their own group most heavily; other groups in the society receive weightings in some sort of hierarchy, with some groups less prized than others from one group's vantage point.

Representing this type of social group influence is accomplished easily in the simulation technology through the differential weighting: members of one's group are simply weighted more heavily, with the consequence that their actions mean more to the decision to voice an opinion than the actions of non-group members in the population. In essence the tie between individuals in a social group is strengthened by the fact that they share social identification.

Two observations about the behavior of populations when social groupings have been accounted for (and networks controlled). First, behavioral contagion across groups is hard to initiate. If the initial set of people voicing a view are all of one group, it is less likely that a second group will also begin voicing a view *unless the number initially voicing this view is large*, in which case it does not matter whether or not there are social groups in the society.This occurs because observers from one social group do not count members of another social group fully when making comparisons with their threshold values. If all those asking for tax reform are X, and I am not X, I am less likely to speak my preference for tax reform than I would be were my social group asking for the reforms.

A second type of effect is found when some groups in the society are given a negative influence on others. This represents the logic that if X

supports the proposition, then I can't possibly voice my agreement because I would never want to be associated with X. This differs from the above situation in that previously all assertion counted somewhat toward the my threshold, but in this latter case some people count negatively—*i.e.* as soon as they begin to voice agreement, I must find more people like me in agreement than before this person voiced agreement.

Interesting dynamics may be produced when these sorts of evaluations or weights are permitted. In the most dramatic instances, whole portions of the population may become silent shortly after one (or a few) individuals they evaluate negatively voice the same preference. This occurs only when those currently vocal are just barely above their threshold for opinion assertion and a small number of the negatively sanctioned group begin to voice the same opinion. This has the behavioral effect of silencing the other group; in the logic of the simulation, the entry of the negatively sanctioned group pushes the $P_{\cdot|i,x}$ (the subjective estimate of support) for the other group back below threshold.

Further, suppose that these two groups are labeled A and B, and that while A evaluates members of B positively, B evaluates A negatively. In such instances it is possible to find oscillation in the group that is asserting the view, even though both hold it. This occurs as a result of the following dynamic: B is vocal, and B is large enough to overcome the thresholds of many members of A, so members of A gradually begin to voice the view (because A evaluates B positively, the assertion of B draws A into the vocal group). However, since B evaluates A negatively, the entrance of more and more members of A into the vocal group eventually begins to force members of B into silence (because B count members of A who assert the view negatively against threshold). As more and more B become silent, members of A also becomes silent because the size of the vocal group is no longer above their threshold. However, their dropping out means that again members of B will voice the view again...

Such a dynamic is rare, however, both in the real world and in the simulations. It is rare because it occurs only under very special circumstances—only certain networks and certain weighting systems will produce this behavior.

8. Opinion dynamics

One of the most fundamental insights of this line of research is relevant to observations about fluctuations in mass or aggregate opinion. Frequently it appears that some idea or viewpoint takes the population by storm, or that it dies out quickly. This research demonstrates quite clearly that no real change in the opinions of individuals in the population need have taken place for even dramatic changes in the number voicing a view to occur. In the simplest example, consider a population all in agreement, but nobody ever says anything because everyone is at threshold 1 or above. If just one or two people begin to voice the view, it can "sweep across the population" quite rapidly; because someone initiated the process, setting the contagion dynamic in motion, and making it OK to voice the opinion for large segments of the population (who held the preference, but were afraid to voice it because they feared nobody else felt as they did—*i.e.* pluralistic ignorance).

Similarly, the dynamic may run in the opposite direction as well. Whole populations may be silenced, though their views not changed, by the removal or silencing of certain key individuals. However, as the simulations have shown, the more complex and fragmented social networks become, the more futile it becomes to try to influence mass behavior by influencing the behavior of any one individual.

One of the most important points relevant to the larger study of public opinion is accentuated by this line of research. First is the notion, mentioned above, that observed changes in public opinion on some issue may be unrelated to real changes in the underlying distribution of preferences. Such changes may sometimes be due to changes in the underlying distribution of thresholds across the population, the entry of new people into (or exit of old from) the vocal portion of the population. This change, while dramatic and similar in appearance to real opinion change, is completely different in fundamental character from a real change in the underlying preference structure.

A related point should serve to caution survey research. The idea that some topics are sensitive, and that on many topics people will give the "socially acceptable answer" is almost identical in character to Noelle-Neumann's (1974, 1984) statement that people are reluctant to publicly voice their opinion for fear of social isolation. Survey researchers have long had methods which attempt to overcome the

socially desirable answer (SDA) bias. Such techniques usually revolve around reassurances of anonymity, suggestions that others hold the view, clinical question phrasing, or utilize statistical uncertainty in a way that provides information to the researcher without compromising the respondent.

However, as Noelle-Neumann's (1984) examples point out, the spiral of silence can plague seemingly non-sensitive areas of public opinion like support for the Christian Democrats. Survey research rarely considers such topics as candidates for serious SDA bias, and hence usually employs only minor guarantees against it in these sorts of questions. Research into opinion dynamics should be informed by such findings as alluded to in this paper and in the spiral of silence theory; much of what we call public opinion or observe as change in opinion may really be levels of public assertion or changes in the proportion willing to vocalize their preference for some position. Finding that 40 percent of some population support the Democrat is different from saying that 40 percent will voice a preference for the Democrat.

Important consequences derive directly from observations about who or how many voice support for some position, however. A policy maker, for example, might judge the desirability or undesirability of some present or potential policy on the basis of how many individuals voice a preference for it at a city council meeting. Or, a Congressman might hold "town meetings" to gauge public opinion. The lesson of the simulations, of Granovetter's work on riots, and of Noelle-Neumann's theory all suggest that such policy making proceeds from rather tenous measures of public preferences. Indeed, making policy in this fashion is policy making best represented with the saying "the squeaky wheel gets the grease" rather than policy making by majority will. Thus, policy errors may occur if policy making proceeds on the basis of public opinion measurements which are really measures of opinion assertion (or vocalization) rather than true measures of the underlying opinion distribution.

Other consequences may also occur. Voicing a preference for a view is but one behavior, and it is argued to be dependent upon whether or not others are also willing to voice the same preference. However, other behaviors may also be affected by the behavior of others.

Voting, for example, is a basic means of decision making in a democracy, and if properly executed it is believed that a vote of the people will result in the will of the majority becoming policy. However,

it is well known that individuals who believe that their candidate has little or no chance of electoral success are less likely to vote than others. If the level of voiced preference for a candidate is taken as the measure of their candidate's chance of success, then electoral outcomes are also influenced by the spiral of silence.

Further, if polls and surveys are influenced by the same reluctance to voice a preference unless some number of others also voice the similar view, then opinion surveys do not overcome the problem, and elections may become self-fulfilling prophesies: the polls indicate that candidate Y has little support, so his (many) supporters look for more viable candidates, or fail to turn out on election day. Such is possible even if candidate Y has a majority of support in the population; because of the spiral of silence he not only fails to generate the enthusiastic public of another candidate, but also loses the election because his "futile" position in the race keeps his supporters from turning out on election day.

9. Feedback

This research is predicated upon the assumption that the behaviors of individuals are interdependent—that a person will voice his preference only if enough others also voice the same preference. Indeed, one key finding of this research is that as networks are more dense and the interconnections among individuals stronger, the more sensitive is the aggregate behavior of the group to changes in the behaviors of certain individuals within the group. Alternatively, as ties become weaker and less dense, individuals are "isolated" decision makers and thus, in this setting, the behavior of the aggregate is not very sensitive at all to changes in the behavior of any individual.

It has been suggested that the dynamic involved in opinion assertion may have serious consequences for both policy decisions and behaviors such as voting. However, it may also have feedback cycles which influence the internal dynamic as well. For example, it was noted earlier that a threshold is a function of the intensity of preference on some issue and a person's aversion to risk (fear of social isolation). Intensities of opinion, like the chance of voting on election day, may be influenced by positive feedback from others; enthusiasm may turn to apathy in the absence of a supportive public. Thus, if $I_{i|x} = f(P_{\cdot|i,x})$ (*i.e.* intensity is some function of the visible level of support), then

there is feedback in the system through the earlier definition of thresholds as $T_{i|x} = f(I_{i|x}, P_{\cdot|i,x})$.

Such feedback systems may not only be endogenous as above, but may also influence the actual opinion distribution as well. Not only may the intensities of preferences be affected through a lack of support, but people may defect from their own initial preference under certain conditions. For instance, if their view receives little attention, at least from the vocal portion of the public, the intensity with which they hold the preference may wane over time. Further, over time, the opposition position on the issue is repeatedly heard, voiced over and over again by its various vocal proponents; eventually it begins to not sound so bad after all, even to some former opponents, and the position begins to win a few more converts.

10. Concluding comments

The dynamic described in this paper began with a simple threshold model similar to the ones used by Granovetter to model riot behaviors. This simple but elegant model enjoys a near perfect fit with the work of Noelle-Neumann on the spiral of silence. The properties of threshold models are easily derived (or simulated), and shed insight into the dynamics of opinion assertion and quiescence. Despite their near perfect suitability as representations of Noelle-Neumann's theory, the simplest threshold models fall somewhat short of a richer representation of opinion dynamics. In particular, they fail to account for the fact that people differ in their importance. Some are opinion leaders, some unknowns. Further, not everyone is able to "see" the same thing because different individuals are tied into different networks. They known different sets of people, have different sources of information, and even different predispositions about others in their environment. Hence, different people evaluate the environment differently.

Though the simple threshold model is well explored and its properties relatively well known, the further realism provided by such factors as social groups, networks, and the phenomenon of opinion leadership comes at the cost of so dramatically altering the basic threshold model that its properties are changed. The added complexity alters the form in such a way that it is no longer easily explored. Simulations provide one means of exploring this more complete model, though there are obvious drawbacks to the simulation approach.

Several important findings are central to the opinion dynamic applications of the threshold model approach. Most important are the findings that center on the impact of networks and opinion leadership. Networks were a proxy for the fact that there are different information sources in a population and that different people are attentive to or knowledgeable of the actions of only a portion of the population. As networks became more or more fragmented, individual decision making becomes less and less sensitive to the actions of others. Thus, a mobilized population becomes more difficult to demobilize as the network is more fragmented, and a quiescent population is more difficult to mobilize. Conversely, as social interconnections become more dense, individual decisions are influenced more by the actions of others, and the behavior becomes collective rather than just serendipitously synchronous.

In a curious twist of logic, this suggests that the more socially integrated a community becomes, the less we need fear problems like "the tyranny of the majority;" despite the potential for rapid mass mobilization of a highly integrated, densely interconnected society, the problems presented by such potentials are of less concern because such a population is also more easily demobilized. In such a situation, if the behaviors of certain key individuals can be influenced, the behavior of he entire community will be affected. By contrast, however, the fragmented community, if mobilized, is extremely difficult to weaken because people must be acted upon individually; key individuals are rare in such a setting, and become more and more rare as the community is more fragmented.

Opinion leadership is possibly only in a setting that is not completely fragmented. If there are no networks, and each individual acts completely in isolation, then there can be no opinion leaders. However, in the range between the fully integrated, ergodic setting and the fully fragmented, atomistic setting, opinion leaders can counter the general tendency for fragmentation to eliminate key actors.

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